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AUTHOR	Bundy, McGeorge
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ABSTRACT

Discussed are the ways in which modern data analysis can increase understanding of complex interrelationships in natural and manmade systems, thus enhancing the rationality of decision-making. Examples are given of predictions made from economic and ecological models. The need for international cooperation on environmental questions is discussed in terms of compatibility of systems for collecting and storing data, free flow of research information, and shared practical effort. Concerns are expressed for the health of higher education in particular graduate education, and for the responsiveness of the political process. Listed are grants made by the Ford Foundation to environmental projects, and books and reports in environmental subjects published in 1968 and 1969 directly or indirectly under Ford Foundation grants. (EB)

Managing Knowledge to Save the Environment

By McGeorge Bundy
A Ford Foundation Reprint

McGeorge Bundy is president of the Ford Foundation. The following address was delivered before the 11th Annual Meeting of the Advisory Panel to the House Committee on Science and Astronautics, January 27, 1970.

Additional copies of this reprint, as well as a complete list of other Foundation publications, may be obtained by writing the Ford Foundation, Office of Reports, 320 East 43rd Street, New York, N. Y. 10017.

A note on Foundation-assisted programs in resources and environment will be found on page 19.

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The subject of your meeting, "The Management of Knowledge and Information," implies in its simple, declarative form a problem, a capability, and a potential, if unrealized benefit.

The problem is that in most, if not all spheres of inquiry and choice, quantities of raw information overwhelm in magnitude the few comprehensive and trusted bodies or systems of knowledge that have been perceived and elaborated by man. I'm thinking here not only of knowledge systems with predictive value, but also of information systematically organized to yield the benefit of comprehensive description. Where, for example, does the novice urban mayor turn to comprehend the dynamic interrelationships between transportation, employment, technology, pollution, private investment and the public budget; between housing, nutrition, health and individual motivation and drive? Where does the concerned citizen or Congressman interested in educational change go for the best available understanding of the relationship between communications, including new technology, and learning? Whom does the modern woman consult when she seeks comprehensive and reliable information on the psychological and biological implications of using "the pill"?

Yet if streams of unassimilated, and often unmanageable, information inundate us even as we thirst for understanding, computer information systems seem to offer unprecedented capability of addressing the age-old problem of integration. They promise this first, because of their vast capacity to store and recall data, and

second, because of their usefulness as a speedy tool in sorting out orders of relationship and dependency between many separately observed phenomena.

And the faith of the modern rationalist is that the family of man can reap important social benefits if it harnesses the capabilities of modern systems of information analysis and storage to convert data into knowledge, and then applies the product as widely as possible to issues of social and personal choice.

If I have correctly stated the elements of the faith framing this assembly and its deliberations, then I register as more, rather than less, of a believer. At the same time, my interest and allegiance is engaged more by the theory and the potential for good of modern information technology than by the present state of the art of application.

The results from employment of computer analysis in the service of policy choice in military affairs and private enterprise have clearly been erratic, and ought to induce caution in other potential users. Even in these areas, where systems have relatively clear boundaries, and objectives allegedly lend themselves to precise specification, experience with application underscores the limitations of this new technology:

—its susceptibility only to data which can be quantified, and the distortions in judgment which will occur when non-quantifiable aspects are badly misjudged, or worse still, omitted entirely from the calculus;

—the direct relationship between the

quality of raw data elements or inputs and the value of knowledge output;

—the necessity that one's theory or explanatory hypothesis bear at least a first approximation to reality.

Indeed, in light of the findings of recent Congressional investigations, one cannot avoid wondering whether it remains possible for even the most sophisticated and rigorous process of analysis to comprehend and master the complexities and uncertainties of modern weapons systems.

An Opening to Rationalism. With these limitations in mind, however, I want to suggest this morning that the endangered environment offers a large and urgent opportunity for exercise of the faith of the contemporary rationalist. If the popular press is any guide, the necessity of preserving and restoring the environment seems finally to have approached the top of mankind's agenda. Fortunately, some sectors of our body politic preceded the current, nearly universal alarm. With important leadership from Congressman Daddario and his sub-committee on Science, Research and Development, Congressmen Saylor and Dingell, and in the upper chamber by Senators Muskie and Jackson, Congress has led the way in suggesting the intellectual, managerial and economic resources that America can and should bring to this worldwide awakening. And while it seems indisputable, as President Nixon insisted last week, that prompt action is required now to restrain the processes that pollute, and sizeable commitments necessary to clean up the messy legacy of earlier indif-

ference, we also have overwhelming need to learn more clearly how the myriad acts of man affect the stability of all of nature's systems.

As the Stanford study group on environmental problems of the National Academy of Sciences has noted in its recent appraisal of "the crisis," we cannot effectively manage the environment without knowing what it is, what it was, and what it can be. At present, we do not comprehensively or regularly measure environmental quality. We do not know how and to what extent it is changing and has already changed. Much of the information now gathered under the aegis of such environmentally oriented agencies as ESSA. the Geological Survey, the Bureau of Commercial Fisheries, the National Air Pollution Control Administration and the Federal Water Pollution Control Administration is obtained for special purposes. Not surprisingly, no agency is either assigned or assumes responsibility for conducting an overall, ecological evaluation of the quality of the environment nor is any common, interchangeable or comparable sampling method now being used, though the quality of the air, for example, quite clearly impinges upon the quality of water.

But if the first requirement is to conceive and install a systematic, comprehensive system of ecological observation and data collection, there is also a large need for analysis; for manipulation of information on a grand scale to identify simple correlations between independently observed and measured phenomena, and for testing of intellectually ambitious models of ecological reality to improve our

powers of prediction and spur our defensive. preventive actions. If it now seems urgent, perhaps even critical to take the largest view of our environment and its interrelating sub-systems, and to address issues of strategic management and preservation, information technology fortunately makes it possible to do so for the first time.

Indeed, some scholars are now coming at environmental analysis from two sides: the economic and the ecological. Both approaches strive to understand the complex interrelationships of the parts of man-made or natural systems, and the causes of equilibrium or instability.

Each approach explores and seeks to identify relationships of dependency between independently observed phenomena. When considering a stream, for example, analysts attempt to define the relationship between discharge of specific amounts of organic materials at specific locations and need of the stream for oxygen at the same locations. Out of a series of such equations, they develop a mathematical model which at its best may represent a primitive skeleton of a complex system. Its formalized, quantitative relationships lend themselves to mathematical manipulation as verbal descriptions of reality cannot. With the goal, for example, of achieving a given standard of water purity in our stream, a good model should enable us to discern the range in cost of several alternative "clean-up" strategies combining elements of plant relocation and modified production methods.

Ecologists and economists have already demonstrated that model-building and

analysis can yield more penetrating insights than might come exclusively from the logic of lay observation or common sense, and can also have practical application.

Mathematical models of whale populations have predicted within a 2 per cent error what the annual catch would be. These models could have been used to fix quotas at a level to protect whale populations and enable them to recover from the tragic overfishing of the past decades. That quotas have not resulted is a political, not a scientific outcome. Better, though still inadequate use has been made of models of the Pacific salmon industry, which show the most effective kinds of restrictions on fishing and which identify the occasions when their application will offer the most protection to salmon.

Economists at Resources for the Future recently challenged a plan by the Army Corps of Engineers to build a number of dams on the upper Potomac and its tributaries. The Corps proposed, in part, to construct these dams to hold water that could subsequently be released in dry season to dilute wastes in the lower river and thereby sustain throughout the year a steady standard of water quality. The agency's critics in R.F.F. constructed a mathematical model of the hydrology of the river basin and explored the cost of a number of alternative methods of assuring the given, as well as higher and lower water standards. They found that all alternatives (combining various treatment methods) were substantially cheaper than the proposed dams, and some would cost only one tenth as much.

To be sure, all these models have or could have practical immediate utility in saving whales, saving money, or insuring water quality. But more important for our purposes, they offer promising evidence that analysis of complexity can enhance the rationality of decision-making. Even if one knows that a reservoir is a more expensive way of keeping the Potomac clean than advanced waste treatment, one may still prefer to keep it clean in this more expensive fashion. Similarly, it is conceivable that a decision to exterminate whales might be deliberately arrived at. It is deliberation that the models make possible and, indeed, in some sense enforce—which is not the least of their social value.

For its part, the Ford Foundation seeks to contribute its full share to the creation of the expanded, action-relevant knowledge about our environment and the threats to it that time requires. Five years ago, the Foundation's Board of Trustees, upon the recommendation of my predecessor, authorized the development of a program in Resources and Environment*. The experience of our increasing effort in recent years suggests to us the very high priority that should be attached to study and appraisal of environment on the broadest scale. We have recently intensified discussions with scholars and public officials on this matter. While we have no formal recommendations as to ways and means to table at this date, we are encouraged to believe that there is a vital, complementary role that philanthropic institutions can play along with Congress, the Executive,

*See page 19 for a description of the program.

other educational and research institutions and indeed the family of nations acting in concert to facilitate the broadened intellectual attack these problems require.

International Environmental Cooperation. The environmental dangers we face, the systems to be understood, and the remedies to be fashioned will frequently be international in character, an aspect properly recognized by the recent, relatively underreported decision of Secretary of State Rogers to create an Office of Environmental Affairs headed by Mr. Christian Herter, Jr. in his office. I personally am convinced that energy for both rigorous study and prompt action must derive from national governments, and not be remanded to or anticipated from supranational agencies or voluntary assemblies of motivated individuals sharing the same concerns or intellectual training across political boundaries. At the same time, I also see important possibilities for international cooperation and collaboration in these urgent environmental tasks.

There is not only the manifest fact of our national interdependencies relative to the environment; there is also no obvious ideological basis for disagreement over causes or relative responsibility, or political gain to be realized from a posture of isolation. Indeed there is some reason to believe that even potential adversaries will welcome and be responsive to an initiative for communication and intellectual consultation on these complex scientific and technical questions. And there is certainly reason to hope that a fruitful intellectual consideration of our common stake in pre-

serving the environment would facilitate discussion of even harder issues of common concern.

In addition to the political possibility for cooperation, there is the undeniable fact that we confront problems of awesome complexity. The intellectual talent which must be encouraged to address these problems is not only exceedingly scarce but also geographically and politically dispersed. Every experience that I have had in exploring issues of common concern with the intellectual and scientific leaders of other societies and states has confirmed what I have always felt in my bones to be true—that the best ideas or perceptions are likely to emerge from circles of intellectual competence deliberately made as inclusive as possible.

Thus as we launch this decade of attention to the environment, there is much to be said for activation and steady cultivation wherever possible of a workable process of international intellectual consultation and collaboration with nationals of countries that may be potential adversaries as well as traditional friends. This process will not happer automatically. It needs to be made someone's business, necessarily requires a new order of collaboration between the State Department, the science agencies, and the nongovernmental Academy, and ought to have Congressional encouragement as well as Executive direction.

One can conceive of three different levels of fruitful international exchange:

First, we should make every effort to insure that national systems for monitoring,

collecting and storing environmental data are compatible. I believe early, serious effort across political boundaries to achieve intellectual consensus concerning the key phenomena to be observed, and the quality indices to be established will obviate dangers of poor or nonexistent linkages between mechanical national arrangements for collection, storage, retrieval and exchange.

Second, assuming as I do that each nation will independently pursue research and experimentation in remedial actions, information on work in progress, results and understandings, however tentative, must flow freely across political boundaries. There simply is too little time, brainpower, and public money for nations to operate either in a chauvinistic or unconsciously introverted fashion; for countries to run up blind alleys trod earlier by others, or remain ignorant of promising approaches under scrutiny elsewhere. The responsibility for insuring the necessary exchange of information in these matters rests with each nation and its interested intellectual community. The priority for public policy here, it seems to me, is the provision of resources for an expanded flow of personnel and information materials from points of national origin, rather than the creation of new, allegedly coordinative international agencies.

Third, when the necessary intellectual mobilization begins to yield operational applications, there will surely be opportunity for shared international effort. The developed countries will have their traditional obligations vis-à-vis the emerging coun-

tries, and new patterns of international law and management seem likely to be required with respect to our priceless, collective oceanic, inner and outer space assets.

Higher Education. The prospects for a successful defense of our natural environment, w ! in our own political sphere as well as in cooperation with others, cannot be insured simply by a commitment to a deeper and broader intellectual inquiry, as fundamental as I believe that is. It will also depend upon at least two other factors which have historically been a concern of this annual gathering and which remain worthy of attention today. I refer,

First, to the health of our system of higher education; in particular, our system at the graduate level for the development of an adequate supply of professionals, skilled in many fields and motivated to tackle these vast, but imperative problems of public choice and policy;

Second, to the health of our political process, its responsiveness to the requirements of national welfare, its capacity for sober deliberation, wise choice and timely, effective action.

I, for one, share the anxiety that many feel today over the adequacy and well-being of each of these vital systems.

With respect to higher education, the problems are many and complex. There is, to begin with, the anxiety that many intellectuals feel at the seeming incapacity of American society to put first things first; the anguish they feel over their perception of a civilization seemingly awash in its own errors and excesses. It would be a serious

error to blink at the increasing estrangement that many of the most gifted in the American Academy, and not just the young, feel toward the values that swirl and prevail in the larger culture and society that encompasses them and their work, and their inclination to withdraw from engagement with problems of that larger scene. At the same time, complementing this external criticism, there is a self-examination and search among many scholars for a fresh and vital definition of the tasks and role of academic men in modern life, an inquiry undoubtedly induced in part by the relentless probes of querulous students motivated to make a difference and not unrelated to the apparent obsolescence of many of the structural forms that have grown up in the contemporary university.

Yet if these enigmatic forces are easier to describe than to reconcile, my quick earlier survey of some of the dimensions of the intellectual challenges of environmental restoration may have suggested my personal conviction that no modern society is going to make it if it fails to connect up its muscular actions to a discriminating intellect. The demand for guidance and understanding by that intellect has never been greater, and not only with respect to the environment, but in the voracious demands of modern society for increased scholarly attention and more powerful intellectual insight concerning the learning process, the aging process, the reproductive process, urbanization, and all the forces compelling human adaptation and institutional change in the technological era.

In my judgment, the ongoing, many-

faceted debate over academic purposes and values will find its focus in the intersection of the important questions of intellectual freedom with forms of educational finance, an emerging problem on the horizon of everyone's consciousness if not yet at the top of anyone's formal agenda. We have finally faced up to the distortions and dangers of channeling disproportionate amounts of federal aid for graduate training, research, and institutional development via the defense budget. We seem increasingly aware, as well, that grants of fragmented financial support for highly specialized, if appropriate educational objectives do not invariably coalesce a coherent or healthy community of scholars and students at point of destination.

But the broader national debate—in part, clearly, a political debate requiring initiation by responsible governmental leaders—which defines and affirms the goals of our system of higher education for both individuals and society, and the terms of national public support and accountability, has barely begun, and is increasingly urgent. In this necessary discussion, the Congress and the public have a right to expect the academic community to come forward in its turn with the professional, curricular, and organizational innovations and protections which an era of protracted engagement with issues of individual welfare and social policy will require.

Political Processes. Finally, I come to the knotty interaction of ideas and action—the capacity of the general and informed public no less than leadership in a democracy to make wise and effective commitments in

policy and program when tested and reliable information is available.

I have argued earlier that the computer can help us achieve a more penetrating and encompassing understanding of the world's natural systems and how man impinges upon them. In the hands of men of powerful and scrupulous intellect, this modern tool can help us define the facts. But I have not asserted, nor do I believe that this intellectual process will define "an answer" or "the remedies."

For action, we must look to politics as the arena where facts are assayed and values collide, where interests compete and policy or stalemate results. And when the needed observation and wider analysis of our threatened environment is further along, I am inclined to believe that the necessary remedies and assessment of damage costs will cut profoundly across many of man's basic values, especially the economic ethic and motor of our existence.

This new knowledge of where we are, and perhaps of how late it is, will also place great strain on our political process. There will be no obvious, consensual and painless technical panacea available to us. We will not be able to avoid a widened definition of the processes of industrial production which embraces the full costs of safely disposing of or recycling waste materials. There will be sharp political conflict over the assignment of these additional cost burdens. There will be a clearer understanding of the price to the current generation of environmental damage unconscionably shunned by earlier eras; we may have indisputable evidence that further procrastination will lead to irreversible de-

struction. In his State of the Union Message, President Nixon has suggested the possibility of a conscious and active national policy of redistribution of population and he has also challenged the assumed identity between economic growth and individual well-being. He has thus identified two of the central topics of a far-reaching national debate on the future quality of our life. The values of our society and the quality of our politics will surely be tested sharply by such choices between adequate and insufficient action; by the assignment of the burden between producer and consumer, between private and public sectors, and between present and future generations.

In that great debate, we will be enormously dependent on the ability of men of scholarship and knowledge to communicate dangers, the range of promising strategies and operational urgencies in terms that are understandable to the general public and to those with political responsibility for action.

We will also need a political process both open and coherent. On the legislative side, it must afford opportunity for representation of view by individuals with a human interest as well as by organized groups with a more tangible economic interest; by the unvoiced, but nonetheless real stake of future generations as well as that of participants in the next general election. And in execution of the generally approved programmatic course, it should be strong enough to avoid bureaucratic splitting of the difference of underlying disagreement, tolerating or encouraging several Executive agencies to operate independently and in-

consistently, undoing with today's directive or action on this side of town what was painfully resolved in someone else's office yesterday.

In the end, effective translation of the desire of man to preserve his environment will depend on the skill of the public man—the capacity of the individual legislator and of the Executive decisionmaker to sift evidence, to discriminate between theories, to interrogate the scientist-scholar, to reach conclusions and to help create the public support for the needed action.

In the era of information explosion, societies can become paralyzed over a plethora of facts and the absence of obvious conclusions. Or they may freeze when the indisputable facts and necessities offend received values and conventional wisdom.

Neither form of paralysis is likely when the linkages between the arena where policy is forged and the relevant circle of informed and disinterested citizens and scholars are firm and easy. This audience and its predecessor gatherings happily embody that value and tradition at its best. The agenda of your common concern is important evidence for the proposition that the discoveries of science and the disciplined intellect intend to serve, rather than overwhelm man as he sets out in a new decade to tackle his unfinished agenda of pollution, pestilence, population, personal productivity, and poverty.

Ford Foundation Grants in Resources and Environment

Although the Ford Foundation's interest in natural resource preservation and management dates back to 1953, when it helped establish Resources for the Future (R.F.F.), an enlarged resources and environment program began in 1964. Currently, the Foundation is making grants at the rate of $6 to $7 million a year in the following general areas:

Training and Research in Resource Management and Systems Ecology. The Foundation has provided the sole support for R.F.F., whose purpose is to advance the development, conservation, and use of natural resources through programs of research and education. R.F.F. has recently been engaged in designing resource management models of such environmental problems as stream and air pollution, pesticide misuse, and urban sprawl. These models are used to determine, for example, the costs and benefits of various alternatives of managing a stream to achieve selected standards of water purity. Grants to R.F.F. have totaled $26,455,000.

Other grants totaling some $6 million have supported training and research in resource management and systems ecology at eleven universities (British Columbia, California, Chicago, Colorado, Johns Hopkins, Manitoba, Pennsylvania, Princeton, Stanford, University of Washington, and Yale) and the Missouri Botanical Garden. The objective of these programs is to train a new breed of conservationist, capable of applying rational principles and methods to the management of resources.

Citizen Education. The Foundation has assisted the Conservation Foundation, the National Audubon Society, the Massachusetts Audubon Society, the Open Space Action Institute, and other groups working to bring educated public opinion to bear on a variety of environmental issues—from preservation of wetlands to checking the indiscriminate use of pesticides. For example, the Massachusetts Audubon Society publishes a magazine, newsletters, and other educational materials and provides consulting services to conservation groups in New England. The Park Association of New York City seeks to develop a constituency for the preservation and upgrading of New York City parks, and National Educational Television received a grant to produce a series of films, for showing in late 1970s, on man's effect on various natural communities of plants and animals.

Preservation of Natural Areas and Open Space. With the exception of a $1.5 million matching grant to Save-the-Redwoods League, Foundation grants to finance land purchase have gone toward the preservation only of areas of special scientific importance. Harvard, the University of California, and the Smithsonian Institution were assisted in acquiring land for biological field stations, and the World Wildlife Fund and the Philadelphia Conservationists received grants for the purchase of coastal wetlands. A $6 million loan guarantee is enabling the Nature Conservancy to acquire parks, forests, and wildlife preserves slated for purchase by governmental agencies but for which public funds have not yet been appropriated. More than 32,000 acres, ranging from tidelands in San Francisco

Bay to an island off the Maine coast, have been acquired by the Conservancy during the past two years with the help of these funds.

Environmental Education. To help schools and other educational institutions make imaginative use of the physical environment as a learning resource, the Foundation has made grants to the Wave Hill Center for Environmental Studies, the Tilton School, the University of Western Ontario, the International Center for Educational Development, and the National Audubon Society. Unlike traditional "nature studies," these programs make heavy use of human resources and physical materials in the immediate local environment to stimulate intellectual growth.

On the undergraduate level, San Diego State College received funds to provide undergraduate biology majors with quantitative training in ecological problems, and Stanford University is developing a new human biology major on the interrelationship of man and the environment. The Stanford program, in which both social scientists and medical school professors are collaborating, seeks to reverse the traditional separation of the biological and behavioral sciences.

Waste Management Demonstrations. Grants have been made to Michigan State University to test the design of a sewage treatment system that will prevent the deterioration of lakes and rivers, and to Harvard University and a Boston community action group to demonstrate a comprehensive approach to the problems of waste disposal in inner-city neighborhoods.

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The Ford Foundation Annual Report.

About the Ford Foundation: General program activities.

The Corrosiveness of Prejudice: by McGeorge Bundy, from the President's Review in the 1967 Annual Report of the Ford Foundation.

Ford Foundation Grants in Resources and Environment: A report of projects in these fields.

New Options in the Philanthropic Process: A report on program-related investments.

The Newsman's Scope: Activities in the field of journalism education.

Planning and Participation: An address by Mitchell Sviridoff, vice president of the Ford Foundation, to the American Institute of Planners, Washington, D.C., January 24, 1969.

Prospecting in Economics: Foundation grants in economic research.

Schools and the Environment: A paper by Edward A. Ames, Foundation program officer in resources and environment, prepared for the American Nature Study Society, December 27, 1969.

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